DECLARATION OF TIMOTHY J. SULLIVAN, Ph.D.

The undersigned, Timothy J. Sullivan, does hereby declare:

In January, 2006, I was retained by the Defendants in this case to perform investigations regarding water quality in the Illinois River watershed and the likely influences of land use on water quality in this watershed.

A. MY BACKGROUND AND EXPERIENCE

1 I have a PhD in biological sciences from Oregon State University, through a multidisciplinary program that involved three areas of focus: environmental chemistry, ecology, and zoology. I have 30 years of experience in environmental effects research, mostly focused on water quality and the impacts of human activities on water quality. I have published over 100 peer-reviewed journal articles, books, book chapters, and technical reports describing the results of this research. I co-founded and have been President of E&S Environmental Chemistry, Inc. since 1988. We conduct environmental research and consulting projects for government, industry, and stakeholder groups. I have also been President of E&S Environmental Restoration, Inc. since 1996. We conduct on-the-ground environmental restoration projects on agricultural and forestry lands, and we also market native grass seed for ecological restoration. I have taught a graduate course in Watershed Science at Rensselaer Polytechnic Institute, NY and several biological science courses at Western State College, CO. Below, I highlight some of my work experience in areas particularly relevant to the Illinois River project.

2 I have experience studying the influence of land use on water quality of lakes, rivers, and streams. This includes about 20 years of experience conducting watershed assessments and spatial analyses using geographic information systems (GIS) to determine relationships between human activities in the watershed and the quality of surface waters.

3 I have managed multiple projects that have examined the influence of human activities on nutrient and fecal bacteria concentrations in river water. Land uses have included agriculture, forestry, rural residential development, and urban development. I have extensive experience managing and writing watershed assessments. Assessment of the contribution of nutrients and bacteria to surface waters, and the effects of such contributions on water quality, are important parts of all of our watershed assessments. Each of these assessments (10 to date) has evaluated water quality of the river system and aquatic/riparian habitat, as influenced by human activities, including forestry, agriculture, urban and residential development, and water use.

4 I have 10 years of experience studying the effects of agriculture, especially livestock operations, on the quality of river and estuary water and the role of best management practices (BMPs) in reducing water pollution. I also have 10 years of experience managing on-the-ground ecosystem restoration projects, especially focused on riparian zones, and implementation of BMPs. Much of this work has occurred in agricultural settings.

5 Some relevant projects have included the following:

- Responsible for synthesis and integration and report writing for watershed assessments/analyses for the Wilson, Trask, Miami, Necanicum, Umpqua Basin (four reports), Upper Sprague, and North Santiam River watersheds in Oregon.

- Principal investigator of project for U.S. Department of Energy to investigate the roles of land use and landscape in the chemistry of surface waters. Involved evaluation of disturbances in the watersheds and comparing them with the chemistry of the lakes.
- Served as project manager for a modeling project to assess aquatic and terrestrial effects of air pollutants in the eight-state southern Appalachian Mountains region for the Southern Appalachian Mountain Initiative (SAMI). Involved investigation of relationships between landscape characteristics (geology, soils, vegetation, elevation, ecoregion) and water chemistry for over 900 streams.
- Assisted the U.S. Environmental Protection Agency to select candidate lakes throughout the United States for possible inclusion as reference waters in the National Lakes Survey, conducted during the summer of 2007. Involved examination of water quality data, construction of maps of land use and land cover within the watersheds of candidate lakes, and examination of aerial photographs of lakeshore areas.
- Served as project manager for several water quality monitoring projects (1996 to 2004) conducted for the Tillamook Bay National Estuary Project and Tillamook Estuaries Partnership to evaluate the concentrations and loads of nutrients, sediment, and fecal coliform bacteria (FCB) in the five rivers that flow into Tillamook Bay, Oregon. These projects include long-term monitoring, storm monitoring, demonstration of environmental remediation, pollutant source area identification, and evaluation of the relationships between land use and water quality.
- Managed demonstration project on agricultural land adjacent to Tillamook Bay, OR to reduce nonpoint source pollution in a cooperative effort with land owners. Included hydrological modifications, wetland enhancement, riparian fencing and planting, culvert replacement, and changes in manure management practices, along with extensive, storm-based water quality monitoring of treatment and reference (control) watersheds.
- Managed research project to quantify the fecal bacteria removal efficiencies of vegetated buffer strips. Research was funded by the U.S. EPA, Oregon Department of Environmental Quality, Tillamook Estuaries Partnership, and Oregon State University Agricultural Research Foundation. Experimental design included installation of buffer strips ranging from 1 to 25 m width on different slope classes, along with zero buffer treatment cells and control cells. Dairy cow manure was applied (all except control cells) to pasture at the uphill buffer interface in advance of storms. Runoff was collected at the downhill buffer interface during rainstorms over a two-year period.
- Managed numerous multidisciplinary watershed restoration projects for the U.S. Forest Service, Bureau of Land Management, Tillamook Estuaries Partnership, and Oregon Department of Fish and Wildlife (1996-2006), including erosion control, riparian planting, fish habitat enhancement (large woody debris and boulder placement and attachment in streams), sensitive vegetation protection, culvert replacement, livestock fencing, road decommissioning, noxious weed survey and eradication, and stream surveys.

- Managed project for the U.S. Environmental Protection Agency to prepare an assessment of environmental effects of emissions and deposition of oxides of nitrogen and sulfur for the 2008 review of National Ambient Air Quality Standards to protect against environmental impacts associated with nutrient enrichment and acidification. Served as primary author of draft materials, including Integrated Science Assessment and associated effects annexes, totaling more than 1,200 pages.

B. BACKGROUND

6 Under the Clean Water Act, lakes and streams can be listed as water quality impaired, or placed on the 303(d) list, based on designated beneficial uses. Within the context of the Preliminary Injunction request by the state of Oklahoma for this case, the beneficial use of river water that is of greatest concern is Primary Body Contact Recreation. It involves direct body contact with the water, for example when swimming, where a possibility of ingestion exists. In a lake or stream designated for the Primary Body Contact Recreation beneficial use, there are limits set for fecal indicator bacteria concentrations during the recreational period May 1st to September 30th. Streams in Oklahoma can be listed as water quality impaired for Primary Body Contact recreation based on one or more of three indicators of possible fecal contamination: FCB, *Escherichia coli (E. coli)*, and *Enterococcus*. *E. coli* is a subset of FCB. In each case, the determination is made as to whether a body of water is to be listed as impaired on the basis of the geomean of a minimum of five samples collected within a period of not more than 30 days. The geomean standards for FCB, *E. coli*, and *Enterococcus* are 200, 126, and 33 colony forming units (cfu) per 100 ml of water sample, respectively. The geomean calculation minimizes the influence of occasional very high values of bacteria concentration that commonly occur in surface water samples. Such high values can result from laboratory or field contamination of the water sample or the presence of one or more fecal particles in the water sample. There are also requirements that no more than 10% of the samples collected in a 30-day period exceed 400 cfu/100 ml of FCB and that no individual sample exceed 406 cfu/100 ml of *E. coli* or 108 cfu/100 ml of *Enterococcus*. (These single sample limits are lower for lakes and high-use water bodies: 235 and 61 cfu/100 ml, respectively.)

7 The approach to evaluation of compliance with Primary Body Contact Recreation standards in Arkansas is different. It is based only on FCB. Between April 1st and September 30th, the FCB geomean shall not exceed 200 cfu/100 ml and not more than 10% of the samples within a 30-day period shall exceed 400 cfu/100 ml. Arkansas also has designated Secondary Contact Waters, used for boating and fishing, in which the FCB geomean shall not exceed 1000 cfu/100 ml nor exceed 2000 cfu/100 ml in 10% of the samples taken in any 30-day period.

8 As I understand it, this preliminary injunction request is focused on the possibility of health risk posed by fecal bacteria. There are other water quality concerns involved in this case that are not part of the basis for the request for a Preliminary Injunction against spreading of poultry litter within the IRW. Of particular note in that regard is the possibility of phosphorus contamination of surface water. It must be emphasized, however, in the context of the request for a preliminary injunction against litter spreading, that the propensity for fecal bacteria to move from a pasture that has been amended with poultry litter to a nearby stream has nothing whatsoever to do with the extent to which the soil in that pasture may or may not have been over-fertilized with phosphorus, or the frequency with which that field

may have been amended with poultry litter in years past. This is because fecal bacteria have a finite life span, which is on the order of days to months. Any bacteria that may have existed within poultry litter that had been added to the field in past years would be long dead, and would not be available to move to, or contaminate, a stream today. Similarly, some of the bacteria excreted by poultry will die prior to removal of the litter from the poultry house, and others will die prior to land application of the litter. Thus, the production of fecal indicator bacteria by poultry should not be considered to be representative of the numbers of bacteria that would be applied to an agricultural field in the act of spreading litter on that field.

9 The propensity for fecal bacteria to move from pasture to surface water is determined by a number of variables, including the loading rate of bacteria to the pasture, the elapsed time between bacterial loading and the occurrence of heavy rain, the intensity and duration of rainfall, the die-off rate of the bacteria in the field (which depends on such things as temperature, moisture, sunlight, and soil conditions), and the movement of water across the fields and into streams. Various practices are available to farmers with which to minimize the extent to which such surface water contamination occurs.

10 Any standing water on, or immediately adjacent to, an agricultural field that has a source of fecal bacteria may contain fecal indicator bacteria subsequent to heavy rain. This is not surprising. However, the occurrence of bacteria in standing water found in, or at the edge of, a field does not indicate that such bacteria will be transported to stream water in quantities that will have a measurable influence on either the concentration of bacteria in the stream or whether that stream does or does not meet Primary Body Contact Recreation standards. In some cases, such field water does not reach a stream without first percolating down through soil, where bacteria can be removed via adsorption to soil. In other cases, some of that field water may actually enter a stream, but the volume of water that does so is too small to have a measurable impact on the concentration of bacteria in stream water or whether that stream does or does not meet bacterial standards. In order for bacteria in field runoff to be quantitatively important to a nearby stream, both the concentration of bacteria in the water AND the quantity of water flowing into the stream must be high enough that the load of bacterial input is high relative to the volume of water in the stream.

11 If any bacteria do reach surface waters from a land-based source of bacteria, they can then be transported downstream. During that transport, some bacteria die and others settle to the bottom and are incorporated into the stream sediment, from which they can be re-suspended during high flow periods or where they may die or be consumed. Thus, as you move downstream, the concentration of bacteria typically decreases. This is an important point because it cannot be assumed that fecal indicator bacteria contributed to the Illinois River system in Arkansas will necessarily survive long and far enough to enter the sections of the river where recreational use is concentrated in sufficient numbers as to cause the concentration to exceed standards.

12 One must be careful not to over-interpret the meaning of a single or a few high values of fecal indicator bacteria in stream water. Because bacteria are so small and because bird and mammal feces contain high concentrations of them, high values of fecal indicator bacteria concentration can derive from inadvertent inclusion of one or a few fecal particles in the water sample. A fecal particle in a water sample can come from a multitude of sources, including duck, goose, livestock, rodent, human, beaver, or deer. Samples of water that are analyzed for bacteria also have the possibility of inadvertent contamination of the sample

with bacteria either by field personnel or in the laboratory. A single high value for bacteria (which can substantially skew an average concentration) has no meaning. This is largely why bacterial standards are based on calculation of a geomean (which is not heavily skewed by a single high value) of five or more samples.

13 One must also be careful not to over-interpret the presence of a mix of constituents in stream water as evidence suggesting that they all derive from a common source. There exist many land-based sources of nonpoint water pollutants. Each land-based source of nonpoint water pollution will have a particular mix of constituents, which might include, for example, various types of bacteria, various nutrients, and various metals. Each constituent will have its own propensity to move from the ground source location into ground water and into surface water. Some constituents move readily; others do not and tend to remain in soil where they can be stored or, in the case of bacteria, die or be consumed. Those that do move to surface water will then mix with point sources that were deposited directly to stream water. For those constituents from land-based sources that do move into surface water, each will exhibit particular behaviors depending on such things as solubility in water, extent to which they settle to the streambed, and in the case of bacteria the die-off rate. The mix of constituents observed at any particular location in a stream is determined by a combination of the source amounts and locations, plus the vast array of chemical, physical, and biological processes that act differently on each constituent as it moves through the terrestrial and aquatic ecosystems. One cannot simply compare the mix of constituents in stream water with the mix of those same constituents in any particular source, and use that comparison to draw conclusions about the relative importance of a particular pollution source.

C. SUMMARY OF MAJOR POINTS

14 I wish to make several points in response to the state's request for a preliminary injunction and the associated affidavits prepared by the state's Experts. They are as follows:

a Neither the occurrence of concentrations above standards of bacteria indicators, nor the levels of those indicators, are unusual in the Illinois River Watershed above Lake Tenkiller (IRW) compared to elsewhere in Oklahoma or other places. *Enterococcus* is commonly above the Primary Body Contact Recreation standard for this indicator under all flow conditions. However, the spatial pattern of *Enterococcus* concentrations in Oklahoma is not consistent with the proposition that poultry litter is an important source of this fecal bacteria indicator. Rather, concentrations of this indicator appear to be common throughout Oklahoma, in areas where poultry operations are numerous and in areas where poultry operations are scarce.

b The concentrations of fecal bacteria indicators in the Illinois River are strongly related to water flow, such that concentrations of bacteria above standards occur primarily during periods of high flow. Under low flow conditions, when I would expect that most on-river recreation (i.e., canoeing) occurs, FCB and *E. coli* tend to be below the standards. This has important implications regarding how surface water fecal indicator data should be analyzed and interpreted.

c A number of breaches of standard sampling procedures by the Oklahoma state field sampling personnel were recorded by Conestoga-Rovers and Associates, who observed, photographed, and shot video footage of some of the state's sampling effort in 2006 and 2007. In my opinion, these procedural breaches that were summarized by Conestoga-Rovers and Associates were sufficiently common and serious as to cast doubt on the validity of the field data collected by the state for this case.

d Contamination of surface waters in the IRW with fecal bacteria is an extremely complex issue. There are many sources of fecal indicator bacteria and they are widely distributed. They are not confined to a single land use or practice. There is no one-size-fits-all solution to the occurrence of concentrations of fecal bacteria indicators above the standards.

D. EXPLANATION OF MAJOR POINTS

Neither the occurrence of water quality impairment nor the levels of fecal bacteria indicators that form the basis for impairment listing are unusual in the IRW compared with waters elsewhere within Oklahoma.

15 Contamination of surface waters by fecal bacteria derived from mammals and birds is a widespread phenomenon throughout the United States, and such contamination is commonly identified using indicators of fecal inputs, especially FCB and *E. coli*. For example, there are 8,695 miles of stream listed by the state of Oklahoma as water quality impaired (303(d) list), and 70% of those stream miles are listed as a consequence of fecal bacteria contamination. Thus, fecal bacteria contamination is the most common cause of stream impairment listing in Oklahoma. Oklahoma stream reaches that are listed for bacteria are shown in Exhibit A, including the basis for listing: FCB, *E. coli*, and/or *Enterococcus*. Such listings are widely distributed throughout the state, including portions of the state that do, and those that do not, contain extensive poultry farming. Exhibit B shows the distribution of poultry farming, by county, from the agricultural census and information provided by Dr. Billy Clay. The poultry industry is primarily confined to eastern Oklahoma, whereas 303(d) listings for bacteria are widespread throughout the state. Furthermore, there are many locations throughout Oklahoma where fecal indicator bacteria concentrations are substantially higher than they are in the IRW. The fact that portions of the Illinois River and its tributaries are listed as water quality impaired as a consequence of bacteria concentrations is not a cause for alarm. The issue is well known and is nationwide in scope.

16 Concentrations of *Enterococcus* above the Primary Body Contact Recreation standards are ubiquitous within the IRW, including sections of the mainstem Illinois River watershed where poultry operations are numerous and sections of the Baron Fork where poultry operations are less common. Such a pattern would not be expected if poultry operations constituted an important source of *Enterococcus* to river water, compared with other sources. The spatial distribution of poultry operations within Oklahoma from agricultural census data (Exhibit B) show that poultry farming is confined primarily to eastern Oklahoma. Similarly, *Enterococcus* concentrations are above the Primary Body Contact Recreation standard at 92% of the locations within Oklahoma where sufficient data are available to calculate a geomean of five samples (Exhibit C). Thus, consideration of the spatial patterns in *Enterococcus* concentrations and poultry farming suggests that sources of *Enterococcus* other than poultry are commonly responsible for the frequent occurrence of concentrations above the standards.

17 The concentrations of fecal indicator bacteria in the IRW are high enough to result in 303(d) listings at some locations, but these concentrations are not unusually high, compared with

values I have seen elsewhere. Again, using the state of Oklahoma as the example, concentrations above standards of all three of the bacterial indicators addressed in the state's request for a preliminary injunction are found to be well distributed throughout Oklahoma (Exhibits C through E). Concentrations within the IRW are not higher than are commonly found elsewhere throughout the state. This pattern holds for *Enterococcus* (Exhibit C), FCB (Exhibit D), and *E. coli* (Exhibit E). Any allegation that fecal contamination in the IRW is unusually high compared to other water bodies, thereby representing an immediate and unusual health threat, is not borne out by the available data. Fecal contamination of surface waters is a national issue, and it has many causes. The IRW does not seem to me to be unusual in this regard.

Fecal bacteria concentrations in river water are strongly dependent on river flow. This has important implications regarding how bacteria data should be analyzed and interpreted.

18 Evaluation of bacteria concentration data for river or stream water must consider the influence of stream flow on bacteria sources. The concentration of FCB or *E. coli* in water within watersheds containing mixed land use varies directly with flow such that concentrations tend to be higher when flow is high and concentrations tend to be lower when flow is low. This is well known to occur essentially everywhere in the United States. The reasons why this is true have to do with the mechanisms by which fecal bacteria from all sources move from the landscape or from a point source to the flowing water. High flow provides the opportunity for waste water treatment facilities to become overloaded with runoff water, creating a sewage bypass, and also provides the transport mechanism to move bacteria from all land-based sources to the water. This pattern is well illustrated using data collected by the State for this case (Exhibit F) which show that the concentrations of FCB and *E. coli* in the Illinois River near the Arkansas/Oklahoma border are usually below both the respective geomean standards and the respective individual (or 10% of individual) sample standards when river flows are low. However, bacterial indicator samples are usually above the standards when flows are high, especially when they are above what I consider to be "high flow", defined here as the 70th percentile of long-term (January 1980 to May 2007) daily average flows recorded by USGS at this site. In other words, 30% of the daily average flows are above the value used to discriminate between high flow and other than high flow, and 70% are below it. The shaded portion of the figures in Exhibit F indicate data collected during high flow periods; nearly all of the bacteria concentrations above the standards collected by the State at this site occurred during high flow.

19 This is important for two reasons. First, one must not try to evaluate changes over time (trends) in fecal bacteria concentration without taking flow into consideration. Second, bacteria concentrations in the Illinois River tend to be above standards primarily at times when one would not expect a great deal of river recreation to be occurring (during rainy periods with high river flows).

20 In Exhibit G, I show publicly available USGS data from the Illinois River near the Arkansas/Oklahoma border (near Watts, Oklahoma), showing changes in the geomean concentration of FCB and *E. coli* over time. At first glance, it might appear that something happened after 1999 that dramatically increased the level of fecal indicator bacteria concentration in the Illinois River. The geomean concentrations for both FCB and *E. coli* increased by more than 10-fold between 1999 and 2000. The state presented a similar trends graphic for this case, based on their calculation of average fecal indicator bacteria

concentrations, and implied that fecal bacteria contamination was increasing over time because of poultry litter spreading. However, the cause of this large increase has nothing whatsoever to do with contamination from the poultry industry or any other potential source of bacteria. The USGS changed its sampling procedures in 1999, such that fixed interval sampling was replaced by sampling that was intended to capture storm events. Thus, the data collected prior to 1999 are not comparable with the data collected after 1999 unless flow is considered. The data presentation in Exhibit G thus shares some, but not all, of the problems I note for the trends graphic offered by the State in this case. I use the appropriate geomean calculation, whereas the State used the inappropriate averaging calculation. Nevertheless, both presentations are biased by the inclusion of few high flow samples prior to 1999 but many high flow samples after 1999. The effect of flow on fecal indicator bacteria concentration can be illustrated by examining the data at this same site, expressed as individual sample occurrences, where each sample is coded according to river flow at the time that the sample was collected (Exhibit H). For this analysis, high flow represents flows in excess of the long-term 70th percentile flow value; moderate flow represents flows between the 30th and 70th percentiles; and low flow represents flows below the 30th percentile of the long-term flow record. Almost all of the high flow samples were collected by USGS after 1999; all of the samples showing high fecal indicator bacteria concentrations were collected under high flow conditions. This pattern is overwhelmingly clear.

21 This series of two Exhibits (G and H), showing different representations of the same data, collected by the same agency, from the same location illustrate an important point. It is noteworthy that these data were all collected by USGS, which has an excellent reputation regarding the quality of their water data. Contrary to the highly misleading graphic offered by the State, purported to indicate an increasing trend over time in bacterial concentrations in the Illinois River, there is no indication in the USGS data that fecal indicator bacteria concentrations at this site have changed over time. Rather, the large differences in bacterial concentrations recorded during the various years are determined by the number of high flow samples that were collected. For years during which many high flow samples were collected, the bacteria concentration values (including the average or geomean of the values) were generally above the standards. For years during which few high flow samples were collected, the bacteria concentration values were generally below the standards. Any representation by the State that such data reflect a pattern of increasing fecal indicator bacteria concentration over time is not accurate.

Breaches of standard sampling procedures by the State's sampling crews call into question the validity of the field data provided by the state for this case.

22 I am especially troubled by the report provided to me by Conestoga-Rovers and Associates indicating that the sampling crews collected water samples from 1) springs that were accessible to cattle, and 2) springs in which the sampling person stood (subsequent to walking across pasture land) prior to collecting the water. If bacterial analyses of spring water are intended to represent the quality of water as it emerges from the ground, thereby representing the quality of the groundwater itself, then the sample must be collected from the point where the spring surfaces from the ground. Furthermore, the sampling person must make sure that there is no possibility of surface contamination of that sample, such as for example from cattle excrement. Cattle are important in this regard because they roam freely throughout pasture lands in the IRW and have direct access to surface waters (including both

springs and streams) at some locations. Thus, where surface waters contain fecal indicator bacteria, such bacteria may be derived from cattle if they are present at the time of sampling or in the recent past (preceding several months). The presence of fecal indicator bacteria in surface water does not indicate that such bacteria necessarily were derived from poultry litter, even if poultry litter had recently been spread on those fields.

23 It is never acceptable to stand in a body of water while sampling that water unless great care is taken to make sure that you are stepping at a location that is clearly down-gradient from the point of sample collection so that you do not inadvertently contaminate the water before you collect it into your sample bottle. This is even more serious if you have walked across pasture land that may have been contaminated with fecal bacteria from cattle or other sources. You should never collect water from a point that is down-gradient from where you just stepped or otherwise disturbed the water or sediment. Documentation provided by Conestoga-Rovers and Associates suggests that such sample collection procedures were violated by the sampling crews dispatched by the State for this case. If the sampling personnel were not aware that the spring samples that they were collecting were intended to represent water quality of the groundwater as it emerged from the ground, and/or if the sampling personnel were not aware of the importance of such potential contamination issues, then I would have no faith that any of the data collected by these personnel could be used to assess the quality of ground water.

24 Conestoga-Rovers and Associates did not observe any of the geoprobe sampling of groundwater in agricultural fields. However, they did observe protocol violations in the collection of soil samples, and these included a range of potential contamination issues, the most serious of which was the collection of samples by driving the sampler through a cow pie. In such a situation, it is likely that the collected soil would be contaminated with material present in the cow pie, and thus would not represent the condition of the soil below the surface. If similar breaches in protocols occurred when sampling groundwater using the geoprobe, then the resulting geoprobe data cannot be used to represent the quality of groundwater.

25 The contamination issues documented by Conestoga-Rovers and Associates are enormously important when assessing bacteria. A very small amount of fecal contamination can result in an erroneous measurement of bacteria that is many-fold higher than any water quality standard.

Contamination of surface water in the IRW with fecal bacteria is a complex issue with no easy, one-size-fits-all solution.

26 The land contributing area of the Illinois River watershed is a complex patchwork quilt of land uses, with a variety of likely bacterial sources to stream water. There are many potential sources of fecal indicator bacteria to the Illinois River that the State has ignored. The most important additional sources of fecal indicator bacteria include livestock, septic systems, overflow from wastewater treatment plants and other sewage bypasses, inadequate toilet facilities for river recreationists, wildlife, and runoff from urban and other developed areas. Because the land uses within the watershed are so patchy (see Exhibit I) and because so much of the urban land use and so many of the cattle (See Exhibit J) are located in the headwater regions of the watershed, it is impossible to discriminate precisely among the various bacteria sources based on observed geographic patterns in bacterial concentration. Headwaters are important because stream flows are lower than further down the stream system, and therefore inputs of bacteria have a larger influence on bacterial concentrations

in stream water. Furthermore, contamination of streams with urban runoff or cattle contributions in the headwater areas makes it difficult to evaluate the importance of potential sources of fecal indicator bacteria in agricultural lands further downstream. These sources of bacteria cannot be ignored in any serious attempt to evaluate the possible causes of fecal indicator bacteria concentrations above standards at some locations in the IRW. It makes no sense to single out the poultry industry as the cause of fecal indicator bacterial contamination in this watershed.

27 There are approximately 314,000 cattle, calves, beef cows, and milk cows in the IRW, based on agricultural census data compiled and provided to me by Dr. Billy Clay. I have observed that these animals have access to streams and streambanks in the IRW in some areas. Clearly, they defecate directly into surface water, or defecate on land immediately adjacent to surface water. Thus, fecal matter from livestock is both directly deposited into streams and is highly susceptible to surface transport to streams during rainstorms. In contrast, fecal matter in poultry litter, when the litter is properly applied, is not deposited in, or located in proximity to, surface water. Cattle (including beef and milk cows) are widely distributed throughout the IRW (Exhibit J). Because these livestock are so numerous and widely distributed, and because they occur in and immediately adjacent to streams in some areas, they cannot be ignored in evaluating fecal indicator bacteria contamination issues in this watershed.

28 Northwest Arkansas is rapidly developing. During the 1990s, this region was the sixth fastest growing metropolitan area in the United States. The human population of cities and towns located wholly, or mainly (more than 50% of township area) within the IRW nearly doubled between 1980 and 2000, from 103,626 to 195,059 people (Exhibit K). The increase in the human population has been especially pronounced since 1990, with an increase of about 69,000 people just during the decade of the 1990s. Construction activities and urban development are widespread throughout the headwaters portion of the watershed. With construction and urban development, there is a substantial increase in the amount of impervious land surface (pavement, roofs, parking lots, compacted soils, etc). Runoff during rainstorms from these impervious areas is largely not directed down through soils (which could remove bacteria from the drainage water), but rather flows overland and through storm drains, providing direct conduits for bacterial transport from the ground surface to stream water. Thus, bacteria deposited on the ground surface by pets, hobby farm livestock, or wild mammals and birds can be efficiently transported from such areas to streams. For this reason, urban areas and developed areas commonly constitute important sources of nonpoint pollutants to streams.

29 According to data compiled by Dr. Ron Jarman, waste water treatment plant effluent within the IRW usually contains about 10 to 40 cfu/100 ml, on average, of FCB. Nevertheless, effluent discharged directly into the Illinois River system sometimes contains levels that exceed the 200 cfu/100 ml Primary Body Contact Recreation standard, including values in the thousands of cfu per 100 ml. Such values of bacteria in the effluent from waste water treatment plants contribute to the overall bacterial concentrations in the streams within the watershed. Dr. Jarman also documented sewage bypasses within the watershed over a period of seven years. Although data were not available from all townships within the watershed, and data were only available for some years in others, Dr Jarman reported about 700 hours of sewage bypass with average quantities of FCB higher than 10^{13} per bypass event (Exhibit L). Most of these bypasses involved raw sewage, in volumes that averaged 500 gallons